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INTERMEDIATE/SENIOR SCIENCE CURRICULUM GUIDE

Pt II

CONTENTS:

ENCLOSURE #3: GEOLOGY: GRADE 12 ADVANCED LEVEL

DRAFT

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GEOLOGY: GRADE 12, ADVANCED LEVEL

Unit	Hours	Unit Title
		PART A
		CORE UNITS
CU 1	3	Planet Earth - An Introduction
CU 2	18	Minerals
CU 3	16	The Earth's Crust - Rocks
CU 4	18	Dynamic Earth
Total Part A =	55	
		PART B
		CORE UNITS
CU 5	7	Extraterrestrial Geology
CU 6	14	Paleontology - Record of Life
CU 7	5	Clocks For the Rocks
CU 8	7	Geological Maps and Illustrations
CU 9	5	Environmental Geology
CU 10	5	Ontario Record - Introduction
		PART B
B		OPTIONAL UNITS - Select any two
		Ontario Record Options:
OU 1	6	. Precambrian Shield
OU 2	6	. Paleozoic Rocks
OU 3	6	. Glaciated Terrain
OU 4	6	. Great Lakes
OU 5	6	. Drainage Basins
OU 6	6	. Ground Water
OU 7	6	. Geophysical Exploration
Total Part B =	55	
GRAND TOTAL =	110	

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GEOLOGY: GRADE 12 ADVANCED LEVEL

INTRODUCTION

The earth is a dynamic planet. Nothing about it is truly static, and none of its features will endure. The universality of change in earth materials results from continuous redistribution of energy. However, the sum of matter and energy in the universe remains constant.

To understand any aspect of the earth requires considering the physical, chemical and biological nature of its parts and their relationship in space and time.

Interpreting the past is possible if features are observed in the light of the belief that processes operating today are similar to those that operated in the past. The earth scientist is often faced with material evidence of great antiquity and large gaps in the record. Using limited data, one must apply knowledge of natural laws and modern processes to explain what is observed.

The teaching of geology should relate, wherever possible, to the student's local environment, and field studies should be conducted that complement the course material.

The geology course may be offered by the geography and/or science departments. A student selecting geology as an elective course for either a full or half credit has the opportunity of designating such a credit as EITHER a science credit OR as a social science credit BUT NOT BOTH.

The course has been divided into an A part and B part, with each being allotted 55 h for completion. Therefore, schools that have chosen to award half credits for their programs may continue to do so with this course. It is strongly advised that the A part be selected for the half credit course for those students who wish to earn only half a credit in geology. Students who choose both parts for a full credit are required to take the A part before the B part. The core units in part A were chosen to provide the fundamental skills and concepts upon which future earth science programs can be built.

The sequence of the four core units presented in part A may be rearranged to suit teacher preferences as long as the students gain the objectives listed in the outlines of the core units in Part A.

Part B contains six core units and a list of seven optional units that are directly related to core unit ten. Two optional units are to be selected to complete the course.

The suggested sequence of the core units and optional units in part B may be rearranged and a judicious combination of core units and optional units may be designed to take advantage of unit time allocations, teacher's expertise and experience, and the local area.

Together, the core units and optional units will give the student a broad spectrum of geologic topics. Thus the student will be able to discuss intelligently issues such as air and water pollution, the disposal of solid, liquid, and nuclear waste, and other geology-related topics which have societal implications. The study of this course may also provide a future hobby or livelihood in a field which demands a geologic background.

Federal and Provincial government ministries, universities, and museums have available many resources that may assist the teaching of this course.

Evaluating Student Achievement

In the Science Curriculum Guideline: Intermediate and Senior Divisions, of which the Geology course will be part, there will be a section dealing with the evaluation of student achievement. The section will outline various aspects of evaluation including suggestions about examinations, tests, and other forms of assessment.

The evaluation of student achievement must be based on the OBJECTIVES, STUDENT ACTIVITIES, APPLICATIONS, and SOCIETAL IMPLICATIONS listed in the various units.

In each unit in the Geology course there is a brief section on EVALUATION OF STUDENT ACHIEVEMENT. These deal only with minimum requirements which are to be treated as mandatory during the term work. In general, 50 per cent or less of the evaluation for a unit is specified in the guideline. Such assessment does not include that performed by formal examinations. The balance of the evaluation for each unit is to be established at the discretion of the teacher.

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Geology - Grade 12 Advanced Level

Core Unit #1

PLANET EARTH - AN INTRODUCTION Time: 3 h

100 INTRODUCTION

Many students will not realize that the earth on which they live and depend on for existence is limited in size and resources. Nor will they know that the earth is an active, dynamic body that changes slowly with time. To use the limited space and limited resources of the earth students should be introduced to how the earth works, what it is made of, and some if its physical properties.

110 OBJECTIVES

111 Attitudes: Students will be encouraged to develop:

a) an appreciation of the importance of geology to society (152);

b) an appreciation of the use of imagery in geology;

c) an objectivity when correlating data to produce generalizations and, eventually, theories about the earth (122, 141);

d) a curiosity about the distribution of geological phenomena (122, 151);

e) an open-mindedness towards research about the earth (126).

112 Skills: Students will develop skill in:

a) viewing the earth as a sphere (123);

b) plotting locations by latitude and longitude (131);

c) plotting selected data by graphs;

d) predicting events in certain regions (122, 134, 152);

e) measuring the size of the earth using one method (136);

f) using maps and atlases (132).

113 Knowledge: Students will be expected to:

a) use or define the terms continent, ocean, sea level, continental shelf, latitude, longitude, mountains, graph, hypsographic, earthquake, volcano, volcanic arc, ocean deep, crust, mantle, core, atmosphere, discontinuity, ecliptic, seismic, epicentre, focus, hypocentre (121-26; 131-36);

b) state the limitations in obtaining direct observations;

c) describe the importance of measurements (131, 134);

d) list evidence for a dynamic earth (125, 131, 134);

e) describe the movement of the earth in relation to the sun (123);

f) describe differences in continental margins (124, 133);

g) list some of the earth's physical properties - e.g., magnetism, gravitational forces (123, 125);

h) identify major features of the earth (121).

120 TOPICS

121 Geographic distribution of major earth structures

122 Geographic distribution of certain geological phenomena

123 The Earth - its size and movement

124 Ocean basins and continents

125 The earth is active to-day

126 The nature of Geology

130 STUDENT ACTIVITIES

The following student activities are mandatory. Students are to:

131 locate seismic and volcanic occurrences on a suitable map of the world;

132 plot a histogram and a cumulative curve to illustrate the difference between continents and oceans (The Hypsographic Curve);

133 participate in a class discussion to follow the plotting of the seismic and volcanic data;

134 participate in a class discussion to summarize differences between continents and ocean floor;

135 write a report on any volcanic eruptions or earthquakes in the news over the summer, or during the school year;

136 determine the size of the earth using one method (194).

140 APPLICATIONS

141 Using skills to co-ordinate data cartographically and

graphically helps identify regional phenomena and their global patterns.

142 An introduction to the study of the earth, helps in the identification of some of the phenomena that require explanation and study.

150 SOCIETAL IMPLICATIONS

151 Societies use geological knowledge to explain natural phenomena.

152 Knowledge of the location of phenomena helps to prevent disasters.

160 EVALUATION OF STUDENT ACHIEVEMENT

At least 20 percent of the term mark for this unit is to be based on the following two components:

161 participation in class discussions;

162 a report on volcanic eruptions or earthquakes as reported in the news.

170 SOME SAFETY CONSIDERATIONS (See Part 1)

180 POSSIBLE EXTENSIONS

181 Determine the size of the earth in co-operation with the class of another school on the same longitude.

190 SOME TEACHING SUGGESTIONS

191 Encourage students to work cooperatively in class discussions.

192 Emphasize the use of maps, graphs and tables.

193 Use audio-visual materials to reinforce ideas.

194 For activity 136, contact a school that is roughly on the same latitude as your school but is more than 100 km away. Both schools should measure the length of the shadow of an object of the same height, e.g., a goalpost, at precisely the same time. Use the data from both schools to calculate the size of the earth.

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Geology - Grade 12 Advanced Level

Core Unit #2

MINERALS

Time: 18 h

200 INTRODUCTION

Minerals are extremely important economically, aesthetically, and scientifically. Economically, minerals are a source of many of the things we enjoy in our current way of life. Aesthetically, minerals enrich our lives as gems, as specimens in their natural surroundings, in collections, and in museum displays. Scientifically, minerals make up the data bank from which we learn about geological processes.

In this unit, students will first learn the definition of mineral and examine the diverse aspects of that definition. Following this, the emphasis will be on how minerals are named and classified, how they are formed, where they occur, and how they are described and identified.

210 OBJECTIVES

211 Attitudes: Students will be encouraged to develop:

a) an appreciation for the beauty that minerals add to our society (224);

b) a curiosity as to how minerals are formed, and the diversity of rocks and minerals in the earth (224, 251).

212 Skills: Students will develop skill in:

a) determining relative density of a mineral (224, 232, 261);

b) determining the streak of a mineral (224, 232, 261);

c) determining the hardness of a mineral (224, 232, 261);

d) determining the cleavage or fracture of a mineral (224, 232, 261);

e) determining the lustre of a mineral (224, 232, 261);

f) using a blowpipe in mineral testing (225, 232, 261);

g) calculating percent element composition knowing the chemical formula of a mineral (227);

h) determining the mineral's name (226, 291);

i) testing for special mineral properties, e.g., magnetic, florescence (224, 261);

j) classifying minerals into native sulphites, oxides, phosphates, silicates, sulphates, carbonates (226);

k) identifying at least twenty-four common minerals (224, 235, 263).

213 Knowledge: Students will be expected to:

a) list certain elements that are abundant in the earth and state their importance, e.g., oxygen (221);

b) briefly review such chemical terms as atom, isotope, ion, molecule, element, compound, mineral, and rock (222);

c) explain some mineral characteristics in terms of atomic structure (224);

d) describe the structure of a silicon-oxygen tetrahedron (223, 233);

e) list and describe the following physical properties used to identify minerals: cleavage and fracture, crystal forms, hardness, colour/streak, lustre, relative density, taste and solubility, magnetism, fluorescence (224, 232);

f) list the main rock-forming minerals (226);

g) describe some chemical tests used to analyze minerals, e.g., reduction using a blow pipe, flame tests, borax bead test for cobalt, closed tube test for sulphur, wet test for sulphur, conversion of pyrite to magnetic residue (225, 232, 241);

h) list the main native mineral groups, e.g., oxides, phosphates, sulphites, sulphates, silicates, carbonates, and locate importance occurrences on a map of Canada (226, 231, 251);

220 TOPICS

221 Abundance of elements
222 Review of some chemical terms
223 Oxygen and silicon tetrahedron
224 Identification of minerals - physical properties
225 Chemical properties of minerals
226 Classification of minerals
227 Composition of minerals - percent composition

230 STUDENT ACTIVITIES

All the following activities are mandatory. Students are to:

231 locate on a map of Canada the main mineral occurrences;

232 conduct experiments on the physical and chemical properties of minerals (291);

233 build models of the basic silicate minerals (293);

234 grow crystals using a solution of copper sulphate, nickel sulphate, or chrome alum etc. (293);

235 identify at least twenty-four common minerals from samples collected or provided.

240 APPLICATIONS

241 A knowledge of the chemical composition of minerals enables the mining industry to develop means of removing metals from their ores.

242 Separation of ions by diffusion through a semi-permeable membrane is caused in part by the fact that different ions may differ greatly in size.

243 A calculation of the percent of metal in metal ores helps to determine whether a mineral deposit can be mined economically.

244 Hardness of diamonds is explained by its three-dimensional network structure. This property of diamonds is very useful in industrial applications;

245 Graphite is a two-dimensional network structure used as a dry lubricant in machines subjected to high temperatures because it is soft and slippery.

246 Garnet and corundum, both metamorphic minerals, are used as abrasives.

250 SOCIETAL IMPLICATIONS

251 Canada possesses abundant natural resources that have allowed it to achieve a high standard of living. These resources have played a major role in creating the nation's wealth.

252 The factors that govern a mine location are complex. Economic advantages must often be weighed against environmental impact.

253 Throughout history, the strength of a nation has been affected by its mineral wealth.

254 Safety hazards accompany the mining of minerals and the manufacturing of mineral products.

255 Science and technology provide the means of converting Canada's mineral resources into useful forms.

260 EVALUATION OF STUDENT ACHIEVEMENT

At least 50 percent of the term mark for this unit is to be based on the following components:

261 skills displayed in performing physical and chemical tests on minerals;

262 laboratory reports;

263 identification of minerals in a practical test.

270 SOME SAFETY CONSIDERATIONS (See Part 1)

271 Caution students to keep minerals away from the mouth and to rinse hands after handling them. Do not perform taste tests.

272 Ensure proper ventilation when students are performing chemical testing with blowpipes.

273 Have students use protective eye-wear and aprons when performing chemical tests on minerals.

280 POSSIBLE EXTENSIONS

281 Perform a lapidary project with minerals.

282 Take students on a trip to the mineralogy gallery at a museum, or an assayer laboratory.

283 Discuss the environmental problems associated with mining.

284 Discuss Canada's responsibilities towards Third World countries who are also involved in mining.

285 Discuss how the physical and chemical properties of minerals can be used in geophysical exploration.

290 SOME TEACHING SUGGESTIONS

291 To become familiar with minerals and their properties, design laboratory exercises in which the students repeatedly handle the same mineral samples.

292 Have the students list the name, properties, and diagnostic features of 20 to 25 minerals. The following minerals are suggested:

silver
copper
graphite
pyrite
galena
sphalerite
plagioclase
hornblende
hematite
magnetite
limonite
halite
fluorite
calcite
apatite
gypsum
quartz
feldspar
garnet
talc
mica
chalcopyrite
barite
sulphur

293 Use fims or slides to reinforce the ideas of grouping minerals according to their physical and chemical properties.

294 Conduct a decision-making simulation exercise involving a hypothetical country containing exploitable minerals. Scientific technical, geological, social, environmental, and economical factors should be taken into account.

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Geology - Grade 12 Advanced Level

Core Unit #3

THE EARTH'S CRUST - ROCKS

Time: 20 h

300 INTRODUCTION

Rock, which represents one of earth's primary components, is characterized by a significant variation in form, appearance, and composition. It is to this non-uniformity that the complexity of the earth's structure can be attributed. Dynamic processes have produced the crustal rocks and it is the varying nature of these rocks that has in turn provided the basis for much of the wealth by which our lifestyles are supported. This unit has been designed to enable students to gain an understanding and appreciation of what is essentially one of the foundations of our existence.

310 OBJECTIVES

311 Attitudes: Students will be encouraged to develop:

a) an appreciation that rocks represent one of earth's primary components (321, 339, 351, 391);

b) an appreciation of the significance of rocks as a primary source in an industrial society (323-25, 334-35, 336-39, 341, 344, 351).

312 Skills: Students will develop skills in:

a) handling rock samples and equipment responsibly (323-25, 336-39, 371-72, 395);

b) using measuring devices and microscopes as an aid to observation (323-25, 336-39, 371-72, 395);

c) drawing inferences from observations obtained through qualitative and quantitative means (323-25, 331-32, 335-39, 342, 373, 393-94);

d) developing charts from given or derived data (323-25, 331, 337-38, 361);

e) classifying rocks according to information derived through an analysis of properties (323-25, 331, 336-39, 341-42, 373, 393-95);

f) performing comparative analyses with respect to different rock samples (323-25, 336-39, 341-42, 373, 393-95);

g) interpreting graphs to further their understanding of rocks and their origins (321-22, 333-34, 343-44, 361, 392);

h) performing experiments from which conclusions can be drawn to reinforce their understanding of processes (321-22, 334, 336, 343, 395);

i) determining degrees of economic values for rocks based on composition (323-25, 331, 337-38, 344, 391).

313 Knowledge: Students will be expected to:

a) use the following terms within the scope of geology: classification (nomenclature), crystallization, foliation, lithification, metamorphism, sedimentation, texture (321-25, 337);

b) use the terms igneous, sedimentary and metamorphic when classifying rocks (321-25, 337-39, 341-42, 351, 391, 393-94);

c) explain how texture of rock provides information about the physical environment in which rock is found (322, 334, 351);

d) recognize weathering as the first step in gradation of rock forms (324, 332-33, 343, 352-53);

e) distinguish between mechanical and chemical weathering (324, 332-33, 343, 353);

f) explain how soils are derived from bedrock (324, 334, 344, 352);

g) describe the formation of a sedimentary rock from a loose sediment using the concept of weather, transport, deposition, sedimentation to form clastic, precipitate, and biogenic rocks (324, 335, 341, 391);

h) explain how crystallization in a magma appears to proceed and how it may lead to different types of igneous rocks (intrusive, extrusive) (323, 331, 342, 391, 393);

i) describe the roles of water, pressure and temperature, in the formation of the metamorphic rocks, and describe contact and regional metamorphism (325, 341, 391);

j) describe the characteristics of individual rocks in terms of composition and texture (323-25, 331, 337-39, 342, 391, 393-94);

k) identify the following (i) igneous rocks; andesite, basalt, diorite, gabbro, granite, obsidian, pegmatite, porphory, pumice, rhyolite, syenite; (ii) sedimentary rocks: coal, conglomerate, dolostone, gypsum, rock salt (halite), sandstone, shale; (iii) metamorphic rocks: gneiss, marble, quartzite, schist, slate (323-25, 336-39, 342, 362, 391, 393).

320 TOPICS

321 Origin of rocks - rock cycle
322 Classification of rocks
323 Igneous rocks
324 Sedimentary rocks
325 Metamorphic rocks

330 STUDENT ACTIVITIES

All of the following are mandatory. Students are to:

331 investigate the composition of a crushed rock (granite) by determining percentage mass and volume of each component (391);

332 perform experiments to illustrate the two types of weathering, mechanical and chemical (395);

333 evaluate the relative importance of different types of weathering under different temperature and precipitation conditions (392);

334 determine soil texture through interpretation of triangular diagrams (392);

335 observe the relationship between settling time and particle size through experimentation (395);

336 experiment to determine the effect of acid on carbonate rocks (373, 395);

337 using a selected set of hand samples, identify rocks from each of the 3 groups (371, 373, 391, 393-95);

338 through use of the microscope, do a comparative analyses of thin sections (372, 391, 393-95);

339 participate in a field study program to observe rocks in their natural setting (371, 373, 391, 393-95).

340 APPLICATIONS

341 Knowledge of rock types and rock structures developed through geologic processes will give an insight into potential mineral deposits.

342 Knowledge of rock composition is significant to the choice of building materials in building and construction.

343 Knowledge of rocks gives insight into earth history essential to solving geological problems.

344 An awareness of weathering processes, particularly in urban areas, can give insight into preventive measures.

345 Variations in soil profiles dictate alternative land uses.

350 SOCIETAL IMPLICATIONS

351 Bedrock is being used for the disposal of nuclear wastes. It is essential that sites be chosen with caution to avoid leakage.

352 Controls on quarry development on the Niagara Escarpment and

other sites is an example of an attempt to maintain land forms.

352 Industry is very dependent on various rock resources. It is essential that exploration in the field and research in the laboratory continue.

354 Considering that a soil profile takes approximately a century to develop, conservation is of the essence.

355 Weathering on rocks has been an accepted natural process but with the increased contribution to acid rain by industry, the effects on rock formations, natural or man-made, may be far-reaching.

360 EVALUATION OF STUDENT ACHIEVEMENT

At least 50 percent of term mark for this unit is to be based on the following four components:

361 developing and interpreting graphs where required;
362 identifying rocks from samples provided;
363 practical laboratory work;
364 laboratory reports and contributions to group activities.

370 SOME SAFETY CONSIDERATIONS (See Part I)

371 Any chipping or fracturing of rocks in the laboratory or field demands the use of protective eyewear.

372 Glass-thin sections must be handled with caution as must the microscope on which they are viewed. Instructions on use and care should be given.

373 Dilute hydrochloric acid only should be used for testing carbonate rocks.

380 EXTENSIONS

381 Trace the changes in a particle of clay as it becomes buried through an increased depth and temperature.

382 Reconstruct the geological sequence of events of a region from which a known rock sample has ben taken.

383 Classify soils into Great Soil Groups.

384 Analyze the sedimentation process through the study of deltaic depositions.

385 Visit a local cemetary to observe rock types and weathering on monuments.

386 Do an interest study on the Greek origin of geologic terms.

387 Do some panning for high-density minerals such as gold.

388 Putting colouration into pottery materials will illustrate how impurities discolour rocks from the normal.

390 SOME TEACHING SUGGESTIONS

391 It is essential that students have a firm grasp of rock forming minerals before beginning this unit.

392 Many charts and diagrams are available which pertain to processes, classifications etc. and it is easy to overwhelm the student. To eliminate confusion, avoid using charts where the content exceeds the requirements.

393 When studying igneous rocks, the task may be simplified by using examples of equivalent combinations, e.g., gabbro and basalt.

394 When studying metamorphic rocks, have available samples of igneous and sedimentary rocks so that different series may be established, e.g., limestone to marble.

395 The laboratory work required in this unit lends itself strongly to team or group efforts, especially with the identifications.

396 If extension 382 is assigned, have available for reference a topographical map of the region to show relief and drainage.

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Geology - Grade 12 Advanced Level

Core Unit #4

DYNAMIC EARTH

Time: 18 h

400 INTRODUCTION

Continents are crossed or bordered by high, rugged mountains. These features occur in broad, roughly curved or linear patterns, whose widths are considerably less than their lengths. On physiographic maps they appear static and fixed. Students should become aware that these mountains have been formed and raised to their lofty heights by tectonic forces originating within the earth. Students should become even more aware that these forces are still at work, and are evidenced by earthquakes and volcanic activity, many of which are associated with the mountains. The coincidence of these associations can be explained by a unifying theory known as Plate Tectonics. The theory can be extended to explain many structures in the rocks of the earth's crust.

410 OBJECTIVES

411 Attitudes: Students will be encouraged to develop:

a) a curiosity about the natural forces that cause volcanoes and earthquakes (421, 426-28);

b) critical-mindedness when using theory (Plate Tectonics) to explain natural phenomena (428).

412 Skills: Students will develop skill in:

a) gathering, correlating and interpreting data from different sources (425, 431-32);

b) assembling data in cartographic form (425, 432);

c) interpreting data from seismograms, e.g., the record of an earthquake (422, 431);

d) determining the location of the epicentres and foci (hypocentres) of individual earthquakes (421, 432-33);

e) application of seismic records to map the earth's interior and determine the size of an earthquake (424, 433);

f) identifying the problems associated with the prediction of earthquakes (425);

g) distinguishing between observation and inference (428).

413 Knowledge: Students will be expected to:

a) define or correctly use the following terms: energy, force, tectonic, seismic, 'P' and 'S' waves, stress and strain, body waves, wave motion, paleomagnetism, isoseismical; magnetic reversals, faults, folds (422, 427);

b) correctly use the vocabulary required to describe the origin and position of earthquakes, e.g., at least 3 types of seismic waves generated by foci, epicentre, hypocentre (422);

c) identify and describe seismic waves generated by earthquakes, e.g., P, S and L waves (422-424);

d) describe the nature and mechanism of an earthquake and its association with faulting (427);

f) describe the nature and manner in which energy is dissipated from an earthquake (424);

g) describe a seismograph and seismogram (422);

h) list the methods used to locate the epicentres and hypocentres (foci) of earthquakes (422, 425);

i) use seismic data to investigate the earth's interior (422);

j) outline the methods used to determine the size of an earthquake (424);

k) describe current methods used to predict the occurrence of earthquakes (425);

l) list mountain ranges where volcanoes occur (426-27);

m) draw and label the elements of faults and folds (427);

n) recognize the directions from which forces were applied to produce faults and folds in the earth's crust (427);

o) identify plate boundaries in the earth's crust from an appropriate map and name the different types of plate boundaries (428);

p) name the six major crustal plates in the earth's surface (428);

q) list evidence for the plate tectonics theory and discuss the merits of the evidence (428);

r) discuss briefly one or two other theories to explain how the earth works (428).

420 TOPICS

421 Earthquakes

422 Seismograms and seismic waves

423 The earth's interior

424 The size of an earthquake

425 Earthquake prediction

426 Volcanoes

427 Mountains and other structures in the earth's crust

428 Continental drift and plate tectonics

430 STUDENT ACTIVITIES

Activities 431-36 are mandatory. Students are to:

431 identify from a seismic trace the 'P' and 'S' and 'L' wave arrivals on a seismogram, and internal reflections of 'P' and 'S' waves;

432 given appropriate data plot travel (transit)-time curves of the 'P' and 'S' waves, determine their velocities and the change in velocities of each as they travel through the deeper zones of the earth;

433 given the data, plot the location of the epicentre of an earthquake; identify as accurately as possible citing the Latitude and Longitude of the epicentre;

434 do a library search to determine where, and how frequently earthquakes occur in Canada; identify the location and the magnitude of the largest Canadian earthquakes;

435 study the isoseismal map of a large eastern Ontario earthquake and identify the probable effects of that shock at the following locations: Toronto, Hamilton, Thunder Bay, Barrie, Sudbury, Ottawa, Kingston, Windsor, London, your school;

436 draw and label explanatory diagrams, or construct models, to illustrate the geometry and nomenclature of faults and folds; identify the directions in which the deforming forces were applied to each structure, and the relationship between the dip (slope) of a fault plane to the direction of deforming forces;

437 construct models, as group projects, to illustrate a seismograph, drifting continents, convection currents, a three dimensional earth, volcanoes, faulting and folding,etc.;

438 visit an institution with seismic recording devices, and/or a field porter;

439 participate in a class discussion on the costs and benefits to society of earthquake prediction.

440 APPLICATIONS

441 Exploration for oil and gas use methods (seismic) whose interpretations are based on a knowledge of the manner in which body waves penetrate rocks of the earth's crust;

442 The geothermal heat energy associated with volcanoes can sometimes be harnessed to heat buildings and generate electricity;

443 Seismic recording stations can be used to detect nuclear explosions;

444 Microseismic events can be used to predict volcanic eruptions and earthquakes.

450 SOCIETAL IMPLICATIONS

451 It is helpful to explain such natural events as earthquakes and volcanoes by scientifically-based statements.

452 It is questionable whether urban communities should be developed in areas subject to severe earthquakes or volcanic eruptions.

453 Research is required into methods of developing building codes designed to minimize damage to buildings and loss of life in the event earthquakes.

454 Earthquakes and volcanic events have changed the course of history within a country, e.g., Pompeii.

455 Dr. Tuzo Wilson, a Canadian scientist, has contributed greatly to our understanding of plate tectonics.

460 EVALUATION OF STUDENT ACHIEVEMENT

At least 50 percent of the term mark for this unit is to be based on the following components:

461 assembling data in cartographic form;

462 accurately interpreting data from seismograms;

463 practical laboratory work and laboratory report;

464 written or oral report based on a library search on earthquakes in Canada.

470 SOME SAFETY CONSIDERATIONS (See Part I)

480 POSSIBLE EXTENSIONS

481 Investigate how knowledge gained from "knowing the earth" is applied to recognize and study "geological" features discovered on the stoney planets and the stoney satellites of the solar system.

482 Discuss how the theory of plate tectonics helps in the search for mineral deposits.

483 Investigate how gas sesimic methods are used in searching for oil and gas.

484 Examine the relationship between the plotting of polar wanderings through geological time and the theory of continent drift.

485 Discuss the disposal of radioactive waste in ocean depths-i.e., trenches.

486 List some of the benefits of volcanic eruptions and earthquakes.

490 SOME TEACHING SUGGESTIONS

491 This unit covers a broad field directed to demonstrate the dynamic nature of the earth. Lessons should be planned carefully. The data presented and the ideas developed should lead to a specific objective. It is not expected that all topics in this unit will be covered to the same depth.

492 A "dynamic earth" implies an evolving earth. Therefore "geological time" should be introduced in a general way while dealing with structures in the earth's crust.

493 Many teaching aids in the form of charts, diagrams, scientific data, and models are available for this unit. The student should not be overwhelmed with such materials; avoid using material with content greater than needed to teach the content of this unit.

494 Audio-visual material should be used to illustrate the physical processes presented in this unit and reinforce the related ideas and concepts.

495 Reference material should be readily available for library-search papers and class discussions.

496 Pose the following question to the class: if you lived in an urban community and an earthquake was predicted to occur within a short period of time, and the method of prediction was known to be accurate, would you leave or remain? If you decided to remain, what precautions would you take?

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Geology - Grade 12 Advanced Level

Core Unit #5

EXTRATERRESTRIAL GEOLOGY Time: 7 h

500 INTRODUCTION

Some of the most exciting pictures to reach the press and television screen in recent years have been close-ups of other worlds in the solar system.

Geologists, geophysicist, and geochemists are now applying the methods used to analyze terrestrial geology to remote-sensed data from extraterrestrial bodies. Scientists now see that what we have learned about the earth can be applied to our planetary neighbours.

510 OBJECTIVES

511 Attitudes: Students will be encouraged to develop:

a) an appreciation for the earth as an extraordinary and wonderful planet (521-26, 593, 595);

b) an appreciation of the extent of scientific research that is devoted to space technology science (521-26, 541, 545, 553);

c) a curiosity about the heavens (521-26, 531, 541, 543, 545, 555);

- d) a respect for the role of the astronomer throughout history (522, 535);
- e) an open mind to new theories (521-22, 551);
- f) an appreciation of the vast amount of data collected by remote sensing by the space missions (521-26, 543, 592);
- g) a questioning attitude about the limitations on the interpretation of remotely-sensed data (521-26, 543, 553).

512 Skills: Students will develop skill in:

- a) inferring on the basis of observation (523-26, 534, 537, 544, 551);
- b) distinguishing between philosophical and scientific questions (521, 551, 555-56);
- c) using appropriate techniques to observe the sun and the moon (522-24, 594);
- d) using some type of optical device such as binoculars or a telescope for viewing the heavens (521, 531, 594-95);
- e) classifying the planets using their physical properties (525);
- f) identifying some bright stars and planets and, where possible, meteors (521, 523, 526, 531, 536);
- g) developing or evaluating theories about the origin of the solar system (522, 551);
- h) plotting moons of a planet, e.g., Jupiter, on an appropriate chart (525, 532).

513 Knowledge: Students will be expected to:

a) define or use the term spectroscopy, and recognize that spectroscopy is used to analyze light emitted from celestial objects to determine the origin and distribution of elements in space (521, 541, 545);

b) compare and contrast the different theories of the origin of the solar system (521-22, 551);

c) describe the past, present, and future of the universe according to each of the three main cosmological models, i.e., steady state, big bang, and expanding universe (521);

d) describe the structure of the sun in terms of its size, interior, and visible surface (523, 545);

e) describe the development of our understanding of the solar system including the contributions of Ptolemy, Copernicus, Galileo, Tycho Brahe, Keppler, and Newton (522);

f) state the laws of Keppler governing the motion of bodies under gravitation (522, 547, 593);

g) compare and contrast the general properties of the nine large planets of our solar system in terms of surface, atmosphere, and interior (525, 531-32, 594);

h) compare and contrast Jupiter and Saturn (525);

i) describe the general features of the moon's surface (524, 531, 594-95);

j) compare and contrast the moon with the earth in regard to geological activity and erosion of surface features (524);

k) give the current theory of the moon's origin (524);

l) explain, in terms of the current theory of comet structure, the changes in a comet's appearance as its distance from the sun changes (526);

m) identify the relationship between comets and meteor showers (526, 594);

n) distinguish between meteoroid, meteor, and meteorite (526, 536, 594);

o) list reasons as to why comets and meteorites are of interest to scientists (526);

p) describe the probable effects on mankind if the astronomical universe were not visible from earth;

q) list ways in which life on earth would be different if the earth did not rotate (522, 524);

r) describe the effect on earth of the following astronomical events; solar flares, meteorites, Van Allen belts (527).

520 TOPICS

521 Origin and distribution of elements in space
522 Dynamics of the Solar System
523 Solar structure
524 Earth and moon
525 Planets and satellites
526 Asteroids, meteors, and comets
527 Astronomical events on earth

530 STUDENT ACTIVITIES

Activities 531 and 532 are mandatory. Students are to:

531 observe with the naked eye, binoculars, or telescope, the moon and one or two of the planets (561, 594);

532 plot the moons of Jupiter over a period of a month (591);

533 observe a meteor shower (562, 594);

534 photograph star trails and/or meteors with a camera (526, 594).

540 APPLICATIONS

541 An understanding of planetary motion led to the deployment of satellites.

542 New technologies, such as satellites, provide new instruments to gather information from space, and allow new methods of collecting energy from the sun.

543 Remote sensing by satellites continuously supplies a vast amount of varied information about the earth.

544 New knowledge gained from the study of the heavens allows scientists to gain a better understanding of the Earth.

545 Celestial navigation relies on an understanding of earth motions.

546 Civil time is largely based on earth motions.

550 SOCIETAL IMPLICATIONS

551 The theories of the origin of the earth and the universe developed by astronomers have sometimes contributed to, and

sometimes conflicted with, theological theories of the origin of the earth.

552 The instant communications supplied by satellites has made it possible for us to be aware of global achievements and conflicts while they are taking place.

553 Space technology has resulted in extensive benefits, but there is also concern about misuse for military purposes.

554 Astronomical events on Earth tend to influence human behaviour.

555 Astrology has influenced the destiny of civilization throughout the ages, and many people throughout history have attributed their shortcomings and responsibilities to astronomical events.

556 Reference grids of topographic maps are based on celestial phenomena.

560 EVALUATION OF STUDENT ACHIEVEMENT

At least 30 per cent of the term mark for this unit is to be based on the following three components:

561 a plot of the moons of Jupiter;

562 written report on direct observations carried out in activity 531 and other selected activities;

563 a written or oral report on the influence on society of an understanding of planetary motion and the resulting technology.

570 SOME SAFETY CONSIDERATIONS (See Part I)

571 Students must not look directly at solar eclipses or the sun with the naked eye, a telescope, or binoculars; such an act can cause permanent blindness.

580 POSSIBLE EXTENSIONS

581 Study the life and further contributions of Keppler, Tycho Brahe, Newton, Copernicus, Galileo, Bode.

582 Discuss U.F.O.'s and the possibilities of extraterrestial intelligence.

583 Construct a simple telescope.

584 Build models of the orbits of a comet.

585 Build scale models of a large earth volcano, a large moon crater, and Nix Olympic.

590 SOME TEACHING SUGGESTIONS

591 Tables and graphs should be used whenever appropriate.

592 Astronomical news items from magazines or newspapers are valuable resources for the classroom.

593 Use visual media to reinforce the characteristics of celestial objects.

594 Plan observing periods on selected nights or for special astronomical events.

595 A trip to a planetarium, where possible, is strongly recommended. Where this is not possible, films can be used to supplement the program.

596 Invite members from the local astronomy centre to give a talk to your students.

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Geology - Grade 12 Advanced Level

Core Unit #6

PALEONTOLOGY - RECORD OF LIFE Time: 14 h

600 INTRODUCTION

The study of fossils and the principles of stratigraphy led to the development of the currently used Geologic Time Scale. The time scale was originally a relative time "calendar" based on events preserved in the fossil record. The value of fossils in revealing the age of rock strata is the result of the widely-held theory that all forms of life have continually and systematically undergone slow changes during long spans of geologic time. The study of life became closely linked to the early developed scale, because the appearance and extinction of animals and plants were used to mark the limits of many sub-divisions on the scale. Students should be reminded that the theory of evolution and paleontology gives only one set of insights into the origin of life on earth. Other fields of study such as religion, philosophy, and astronomy influence personal hypotheses on the origin of the universe and the life in it.

610 OBJECTIVES

611 Attitudes: Students will be encouraged to develop:

a) a questioning attitude towards theories of the development of life on earth (624-28, 635, 646, 653);

b) an appreciation for the role of fossil study in the science of geology (624-28, 642, 647);

c) an appreciation of fossils as indicators of depositional environment, and the importance these indicators to petroleum geologists (622, 644-45);

d) a curiosity in collecting fossils (621, 629, 631, 692, 697);

e) an open mind when studying geological time and the timing of major evolutionary events (635-36, 646-47).

612 Skills: Students will develop skill in:

a) carrying out laboratory and field study techniques, including sketching fossils and preparing peel sections from samples and outcrops (623, 629, 631-34, 693);

b) recognizing and identifying several common fossils both from whole specimens, and from fragments (621, 623, 629, 631, 643, 691);

c) classifying fossils in their proper phylum (623);

d) extracting and cleaning fossils from rock (621, 629, 632-33);

613 Knowledge: Students will be expected to:

a) describe the processes by which organisms where preserved in rocks (621);

b) define or use properly the term phylum in relation to classification of organisms (623);

c) name the types of fossils found in Precambrian rocks (624);

d) describe the life in the Paleozoic and the range of important groups of fossils (625);

e) describe the life in the Mesozoic and the range of important groups of fossils (626);

f) describe the life in the Cenozoic and the range of important groups of fossils (627);

g) list ways in which the fossil record reveals information concerning the environment in each of the periods studied (622);

h) trace the evolutionary history of at least one organism (628, 635, 646);

i) state the important fossils for the following: protozoa, porifera, coelenterata, annelida, bryozoa, brachiopoda, mollusca, arthropoda, and chordata (623, 631);

j) state reasons for the importance of index fossils (622-28, 642-43);

k) explain how the fossil record contributes to the theory of biological evolution (628, 697).

620 TOPICS

621 Fossils and fossilization

622 Fossils as indicators of environment

623 Fossil classification and morphology

624 Life in the Precambrian

625 Life in the Paleozoic

626 Life in the Mesozoic

627 Life in the Cenozoic

628 Patterns of evolution

629 Where and how to collect fossils and their uses

630 STUDENT ACTIVITIES

Activities 631-32 and 634 are mandatory. Students are to:

631 carry out laboratory exercises (including sketching) with fossils;

632 prepare acetate peels of fossils;

633 apply the techniques for cleaning fossils;

634 carry out field studies from outcrops;

635 graph the geological history of earth using our present-day calendar year as a time scale (653).

640 APPLICATIONS

641 Sedimentary rock exposures are correlated on the basis of their contained fossils.

642 Fossils are used to mark historical events of earth history.

643 Petroleum geologists use fossils and microfossils in the search of oil and gas because oil and gas are believed to have been derived from fossils.

644 Fossil assemblages are used to indicate past environments.

645 Paleogeographic features of the earth's crust can be inferred from fossils.

646 Fossils contribute evidence for the study of evolution.

647 The geological time scale gives geologists a framework of time in which to explain earth processes.

650 SOCIETAL IMPLICATIONS

651 Fossil fuels are one source of energy for our present industrial society.

652 The vast number of petroleum byproducts contribute to a high standard of living.

653 The concept of evolution based on fossil evidence continues to be a controversial topic.

660 EVALUATION OF STUDENT ACHIEVEMENT

At least 30 per cent of the term mark for this unit is to be based on the following three components:

661 laboratory and field study work;

662 laboratory reports;

663 the identification of some common fossils.

670 SOME SAFETY CONSIDERATIONS (See Part I)

671 Caution students to use care when working with acids.

680 POSSIBLE EXTENSIONS

681 Study microfossils as a positive correlation for separating events on a strata.

682 Study the historic development of our ideas on evolution including the contributions of Lamarch, Cuvier, Darwin, and Wallace.

683 Perform a library search of the exploration methods used in the petroleum industry.

684 Write a report on the oil and gas industry in Ontario.

685 Study the geologic history of Homo sapiens.

686 Construct model reptiles from commercial sets.

687 Construct dioramas for different geological eras.

688 Discuss reasons for the extinction of species.

690 SOME TEACHING SUGGESTIONS

691 Design laboratory exercises so that students are required to sketch the fossils.

692 Have fossils in the hands of each student during the discussion.

693 Have students name and describe the features of 10 to 15 fossils.

694 Have students consider the validaty of inferences drawn from a study of fossil tracks.

695 Use visual media to reinforce and illustrate fossil characteristics.

696 Some form of related field study should be conducted.

697 A visit to the paleontology galleries of a museum should be planned if at all possible.

698 Discussion of various aspects and points of view on evolution must be handled sensitively and with tact. Emphasize that although the theory of evolution is widely accepted in the scientific community, it is nevertheless a theory and hence tentative and subject to change as new evidence is presented.

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Geology - Grade 12 Advanced Level

Core Unit #7

CLOCKS FOR THE ROCKS

Time: 5 h

700 INTRODUCTION

A dynamic earth is a changing earth, and therefore one picture of the earth is a historical picture. The fundamental component of such a picture is time - time determined from the layers of rock that form the earth's crust, from the radioactive minerals found in them, from fossil wood, from tree rings and from the rates of certain geological processes. These data are the key to grasping the magnitude of the time-frame through which the earth has evolved, and hence the key to understanding geology and interpreting geological processes.

710 OBJECTIVES

711 Attitudes: Students will be encouraged to develop:

a) curiosity about measurable events of the earth's geologic past (721-728, 731-733);

b) an appreciation for the concept of geologic time and its measurement as being one of the most important aspects of geology (721-28, 733, 741-42, 751);

c) an appreciation for the necessity of correlating events within the solar system (721-28, 741, 792).

712 Skills: Students will develop skill in:

a) solving numerical problems relating to geologic time (721-28, 731, 741-42);
b) graphing data derived through laboratory investigations (728, 732, 791-92);
c) organizing data pertaining to geologic age into a time scale (721-28, 731-32, 741);
d) inferring the nature of past environments based on evidence presented by geologic dating (721-23, 733, 741);
e) predicting future geologic occurrences based on the records of the past history (721-28, 731-32, 741-42).

713 Knowledge: Students will be expected to:

a) define the following terms: dendrochronology, radioactivity , varve, isotope, half-life (722, 728, 732);
b) list the various techniques used for geological dating and state the strengths and weaknesses of each method, i.e., dendrochronology, varve counting, carbon - 14, oceanic salt accumulation, sedimentation, erosion, earth cooling, radioactivity (721-28, 731-32);
c) distinguish between relative and absolute geologic dating methods (721-28);
d) explain how a given formation or event may require a specific dating technique (721-28);

e) apply their knowledge of geologic dating towards an understanding of the earth's chronology (741-42, 751);

f) explain how evidence gained through geologic dating may reflect past environments (721-23, 741, 751);

g) list the limitations of each dating method used to determine geologic age (721-28);

h) state the requirements for measuring time (721-28, 733, 742, 792);

i) state the sequence of events and the correlation of events in time (721-28, 741, 751, 791).

720 TOPICS

721 Dendrochronology
722 Varve counting
723 Carbon-14
724 Salt accumulation
725 Sedimentation
726 Erosion
727 Earth cooling
728 Radioactivity

730 STUDENT ACTIVITIES

All of the following are mandatory. Students are to:

731 calculate the rate of retreat of Niagara Falls given the total distance eroded since glacial retreat (791);

732 conduct an experiment which illustrates how radioactive decay proceeds and then draw a typical decay curve to predict half-life.

740 APPLICATIONS

741 Carbon-14 dating techniques can be used to establish a time frame for archaeological sites.

742 A knowledge of sedimentation rates or erosion rates can assist in planning water control measures.

750 SOCIETAL IMPLICATIONS

751 The reconstructing of past environments will indicate periods of climatic change. This information becomes useful in projecting future climatic trends.

760 EVALUATION OF STUDENT ACHIEVEMENT

At lease 40 per cent of the term mark for this unit is to be based on the following three components:

761 proficiency in doing investigations and calculations;

762 written explanations of geologic dating applications;

763 accuracy of problem solving and graph work.

770 SOME SAFETY CONSIDERATIONS (See Part I)

780 POSSIBLE EXTENSIONS

781 On an enlarged map of the Niagara Gorge, mark on in strategic locations, significant historical events which correspond to specific points of retreat of Niagara Falls.

782 With a geiger counter, test a sample of rock for degree of radioactivity.

790 SOME TEACHING STRATEGIES

791 Stress the use of graphs and diagrams to illustrate geologic dating methods, especially those for which there are no activities.

792 In discussing the requirements for measuring time the following points should be included:

a) the rate at which the process is taking place today has to be known;

b) the law expressing the variation of the rate during the interval of time being measured;

c) the total change affected by the process during that interval.

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Geology - Grade 12 Advanced Level

Core Unit #8

GEOLOGICAL MAPS AND ILLUSTRATIONS Time: 7 h

800 INTRODUCTION

Geologists are interested in studying the deformation of rock, i.e., their structure, to determine when and how they formed. That a rock body undergoes deformation is ascertainable only if pre-existing features, such as bedding planes or fossils of known shape and orientation, are known.

Nearly all geological knowledge is based on the results of field work. The various modes of expression of geologic data are presented to allow the geologist to think in three dimensions.

A knowledge of formations below the surface is important to engineers and construction designers. In addition, many valuable mineral and natural resources are associated with rock structures.

810 OBJECTIVES

811 Attitudes: Students will be encouraged to develop:

a) objectivity in viewing geologic maps (827, 831);

b) confidence from and satisfaction in using process skills (822, 827, 831, 836);

c) an appreciation of manual skills in presenting geologic data (822-27, 831-36, 893-94).

812 Skills: Students will develop skill in:

a) measuring and plotting the attitude (strike and dip) of a rock bed (824-26, 883);

b) gathering data from various sources (822-27);

c) plotting data on maps (822-27);

d) making hypotheses based on geologic maps and sections (822, 827, 831, 894);

e) inference-making from geologic maps and cross-sections (823-27, 894);

f) measuring and plotting pace and compass traverses (822, 833);

g) visualizing three dimensional objects in air photos using a stereoscope (821, 836, 893).

813 Knowledge: Students will be expected to:

a) review features of topographic maps, such as contour line and contour interval, latitude and longitude, and drainage (821, 891);

b) make measurements of heights and slopes from air photographs (821, 836);

c) state the laws of Nicholas Steno and James Hutton (823);

d) label the elements of a fault and a fold (825-26, 832-33, 892);

e) explain geologic cross-sections (824-26, 832, 894);

f) correlate stratigraphic columns (827, 834, 895);

g) make block diagrams of geologic structures (823, 826, 893).

820 TOPICS

821 Topographic maps and air photos

822 Outcrop maps

823 Horizontal rock strata

824 Inclined rock strata

825 Folded strata

826 Faulted strata

827 Stratigraphic columns

830 STUDENT ACTIVITIES

All of the following are mandatory. Students are to:

831 draw geologic plan maps with inferred contacts (893);

832 draw geologic cross-sections (893);

833 measure strike and dip (826);

834 draw fence diagrams given a series of stratigraphic columns (893);

835 conduct a pace and compass traverse;

836 determine heights of objects from air stereo photographs (892).

840 APPLICATIONS

841 Geologic maps are used to locate favourable engineering sites and areas for resource exploration, development and land use.

842 Geologic sections are used in locating valuable resources.

843 Geologic maps and section are a convenient means to present a vast amount of data.

844 Air photographs are used to locate geologic outcrops and geologic structure and to set up preliminary exploration of an area.

850 SOCIETAL IMPLICATIONS

851 Geologic maps benefit an urban development by helping identify suitable sites for waste disposal, buildings, etc.

852 Geologic maps indicate hazardous areas, e.g., earthquake-producing faults, so that building structure can be designed to accommodate such things as faults.

853 Stratigraphic sections are used to help locate ground-water, oil and gas concentrations. Their use increases the success ratio of exploration and hence increases standard of living.

860 EVALUATION OF STUDENT ACHIEVEMENT

At least 50 per cent of the term mark for this unit is to be based on the following four components:

861 skill in drawing geologic plan maps and cross-sections;
862 skill in measuring strike and dip;
863 successfully conducting a pace and compass traverse;
864 properly interpreting a three-dimensional airphoto using a stereoscope.

870 SOME SAFETY CONSIDERATIONS (See Part I)

880 POSSIBLE EXTENSIONS

881 Construct models of geological structures from plasticene or styrofoam.
882 Study material on the life of Nicholas Steno and James Hutton.
883 Plot drill hole intersections of ore bodies.
884 Discuss subsurface contour.
885 Correlate electric well log data.
886 Observe selected geologic structures with a stereoscope.

890 SOME TEACHING SUGGESTIONS

891 Use visual media to reinforce the characteristics of geologic structures.
892 Use models to reinforce the three dimensional aspect of geologic structures.
893 Have students construct outcrop maps and geologic cross sections.
894 Have students construct stratigraphic sections (fence diagrams).

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Geology - Grade 12 Advanced Level

Core Unit #9

ENVIRONMENTAL GEOLOGY

Time: 5 h

900 INTRODUCTION

The environment is a dynamic system. Whether changes that occur are continuous or catastrophic, any geological event may still be designated a natural hazard if it results in destruction to humans. In addition, however, human activity itself has become a major agent of geologic change. Intent on self improvement, byproducts of the modifications made by humans have created further environmental hazards. The main issue confronting society is whether humanity can assume the responsibility necessary to maintain its own geologic environment.

910 OBJECTIVES

911 Attitudes: Students will be encouraged to develop:

a) a respect for the natural environment and an awareness of its dynamic structure (921-28, 936, 943, 952, 991);

b) a concern for those environmental hazards that are predictable and can be avoided (921-28, 931-33, 941-43, 951-52, 992);

c) a concern for the possible adverse effects resulting from the environmental modifications imposed by society (921-23, 925-26, 928, 931-33, 942-43, 952);

d) a commitment towards the maintenance of our natural environment (921-23, 925-26, 928, 931-33, 942-43, 952).

912 Skills: Students will develop skill in:

a) predicting the environmental response to the current sustained activities of man (921-23, 925-26, 928, 931-33, 941-43, 951, 992-93);

b) interpreting, from geologic maps, information pertinent to gaining an awareness of potential environmental hazards (921-23, 927, 931-32, 936, 941-43, 951, 992-93);

c) evaluate the negative impact of a geologic event upon the environment and relate the magnitude of the event to the negative impact (923, 925, 927, 933-35, 942, 951, 992-93);

d) graphing data to illustrate trends in a continuous geologic event (924, 926, 933, 934, 941-42, 951, 992-93);

e) projecting human response to accommodate an event which presents an environmental hazard (923-24, 927-28, 934-36, 941-42, 951-52, 992-993).

913 Knowledge: Students will:

a) explain how improper waste disposal can affect the hydrologic conditions and contaminate groundwater (921, 926, 928, 932-33, 952, 992-93);

b) state possible actions for the rehabilitation of abandoned quarries and open pit mines (922, 932, 941-42, 952, 992-93);

c) explain the principles involved in the occurrence of landslides (923, 935, 941-43, 951, 992-93);

d) describe measures to prevent or control shoreline erosion and flooding (924, 934, 941-43, 951, 992-993);

e) identify the factors which initiate flood action within drainage basins (925, 928, 931, 941-42, 951-52, 992-93);

f) apply geologic awareness towards the prediction, preparation and prevention of earthquakes and volcanoes (927, 941-43, 951, 992-93);

g) explain the role sulphur dioxide or carbon dioxide have in modifying the environment (921, 926, 942, 951-52, 992-93);

h) describe possible repercussions the establishment of a powerdam may have on a drainage system (925, 931, 942, 951, 992-93);

i) explain how urban land use can often be dictated by the natural environment (928, 936, 942-43, 952, 992-93).

920 TOPICS

921 Waste disposal and groundwater contamination

922 Quarries or open pit mines

923 Landslides and land subsidence

924 Shoreline erosion by flooding

925 Power dams and drainage systems

926 Sulphur dioxide or carbon dioxide in the atmosphere

927 Effects of catastrophic earthquake or volcanoes

928 The urban environment

930 STUDENT ACTIVITIES

Activity 931, one of 933-35, 937 and two others are mandatory. Students are to:

931 given a detailed drainage basin on a topographical map, predict the total impact a power dam would have on the environment (991-93);

932 given an abandoned quarry site, establish a rehabilitation plan compatible with the surrounding landuse (991-93);

933 trace the total effect that the emission of sulphur or carbon oxides will have on the natural environment (991-93);

934 graph the rate of recession of an erosion shoreline to correlate with changing lake levels (991-93);

935 determine, through analysis, the physical impact a major catastrophic event (landslide, earthquake, volcano) would have upon the environment using quantitative data where possible (991-93);

936 do a land-use study of an urban centre susceptible to catastrophic geologic activity to investigate human awareness and response (991-93);

937 prepare a report on an environmental hazard not discussed in class; the focus should be towards environmental protection (991-93).

940 APPLICATIONS

941 The knowledge of geology is useful in making both short-term and long-term decisions pertaining to the environment.

942 Future development can minimize natural hazards by avoiding high risk areas.

943 Recognition of the constraints that the earth places on its exploitation is a first step in developing opportunities for continued growth through effective land and water management.

950 SOCIETAL IMPLICATIONS

951 As the use of earth science grows, so will the ability of the science to devise means of collecting and applying data.

952 As people continue to concentrate in cities, earth science becomes increasingly important in maintaining an acceptable environment.

960 EVALUATION OF STUDENT ACHIEVEMENT

At least 50 per cent of the term mark for this unit is to be based on the following three components:

961 appropriate use of data or graphing in activity 933, 934, or 935;

962 written reports from student activities;

963 written or oral report on an environmental hazard as outlined in activity 937.

970 SOME SAFETY CONSIDERATIONS (See Part I)

980 POSSIBLE EXTENSIONS

981 Test the pH values of natural waters for effects of acid rain.

982 Survey an active land slump over a period of time.

983 Participate in a local field trip designed with an emphasis on environmental geology.

990 SOME TEACHING SUGGESTIONS

991 Considering the time allotted for this unit, it is advised that at least four topics be chosen from the topics list and treated as class discussions. A fifth topic can then be assigned for the report in activity 937. The remaining topics can be treated in any manner deemed appropriate.

992 Case studies should be utilized when possible not only in student activities but also during class discussions, e.g., Turtle Mountain landslide or James Bay Power Project.

993 Because this unit lends itself to a great deal of open-mindedness on the part of the student, it is suggested that group work be a common teaching technique.

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Geology - Grade 12 Advanced Level

Core Unit #10

THE ONTARIO RECORD (INTRODUCTION) Time: 5 h

1000 INTRODUCTION

This is an introductory unit designed to provide an overview of the geologic data base of the Province of Ontario.

The unit is followed by seven optional units (OU#1 to OU#7 inclusive) of six hours each, from which two must be selected.

The combination of Core Unit #10 and the choice of two optional topics provides opportunities for making full use of local environments and teacher expertise.

1010 OBJECTIVES

1011 Attitudes: Students will be encouraged to develop:

a) an appreciation of the fact that the geologic record of the Province of Ontario is far from complete in relation to the record of North America as a whole (1021-22, 1031-32);

b) an appreciation of the glacial history recorded in Ontario and its relationship to the physiographic features of the Province (1023, 1042-43);

c) an appreciation of the geological heritage of the province and the importance of both renewable and non-renewable resources and their influence on regional development (1024, 1034, 1041, 1051).

1012 Skills: Students will develop skill in:

a) interpreting the geologic history of the Province of Ontario from geological maps and diagrams (1021-23, 1032);

b) interpreting the distribution of provincial natural resources as related to geological factors (1021-25, 1034, 1041, 1051).

1013 Knowledge: Students will be expected to:

a) identify such geologic features in Ontario as the Canadian Shield and its "provinces", the Grenville Front, Penninsular Ontario, Great Lakes, Ottawa-Bonnechere Graben, Niagara Escarpment and the James Bay Lowlands (1021-22, 1032, 1041);

b) list the major rock types found in Ontario and their record in time (1021-22);

c) name some major geological events relative to the rock types studied in (b) (1022-23);

d) relate the effect of major structural features of the bedrock on the terrain of Ontario, particularly with respect to water resources and drainage (1025);

e) establish the role of the bedrock in controlling the distribution of such features as the Great Lakes, Ottawa River, the Niagara Escarpment, and Niagara Falls (1021-22, 1032).

1020 TOPICS

1021 General geology of the Province of Ontario

1022 Bedrock geology of Southern Ontario

1023 Glacial features of Ontario

1024 Mineral deposits

1025 Water resources and the drainage of Ontario

1030 STUDENTS ACTIVITIES

All of the following are mandatory. Students are to:

1031 prepare a map of the province of Ontario, outlining the major geological features (1041-42);

1032 use records from bore-holes to obtain data from which to draw a diagram (stratigraphic column) to illustrate the bedrock that underlies Southern Ontario (1041-42);

1033 identify the major geologic features in the immediate vicinity of their school (1052-53, 1081);

1034 prepare a mineral location map of Ontario and relate it to the geologic map of Ontario (1041);

1035 locate the major aquifers in Ontario and establish their relationship to their geological environment.

1040 APPLICATIONS

1041 Knowledge of rock types and rock structures will give an insight into the location of potential resources, both non-renewable (mineral) and renewable.

1042 Knowledge of bedrock and its distribution beneath glacial deposits, and the glacial history are essential to understanding changes in drainage patterns.

1043 Variations in glacial deposits dictate alternative land uses.

1044 The location of waste and toxic elements disposal sites is dependent upon properties of the bedrock and glacial deposits.

1050 SOCIETAL IMPLICATIONS

1051 Ontario's industry and urban centres are highly dependent on various geological resources. It is essential that exploration in the field and research in the laboratory continue to maintain adequate reserves (where possible) of both renewable and non-renewable resources.

1052 Disposal of industrial and urban waste and toxic materials requires a knowledge of earth materials.

1053 Recreational and scientific reserves are related to geological and physiographical features.

1060 EVALUATION OF STUDENT ACHIEVEMENT

At least 50 percent of the term mark for this unit should be based on laboratory records and map skills.

1070 SAFETY CONSIDERATIONS (See Part I)

1080 POSSIBLE EXTENSIONS

1081 Field excursions should be conducted to nearby geologic features, and further afield if justified.

1090 SOME TEACHING SUGGESTIONS

1091 This unit, in addition with two optional units, may form a strong local unit.

1092 Much of the data for this unit may be obtained from both provincial and federal government publications.

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Geology - Grade 12 Advanced Level

Option Unit #1

PRECAMBRIAN SHIELD Time: 6 h

100 INTRODUCTION

The Precambrian era represents more than three-quarters of the history of the Earth. It is believed that it began with the formation of the earth and its oldest known rocks; it ended some 600 000 000 years ago with the earliest Paeleozoic formations. Because of the scarcity of fossils in Precambrian rocks, their greatly disturbed and metamorphosed condition, and their lack of continuity of exposure, great difficulty has been experienced in deciphering the history of this period.

The rocks of the Precambrian shield occupy more than two-thirds of the surface of Ontario and have had a complex history of igneous activity, sedimentation, and metamorphism. Within these Precambrian rocks associated with volcanism are the ores of nickel, copper, iron, zinc, gold, uranium, and other valuable metals.

110 OBJECTIVES

111 Attitudes: Students will be encouraged to develop:

a) a curiosity about the early events in Earth History (121, 122, 124);

b) an appreciation of the complexity of the problem of trying to determine the different stages of the Precambrian era (123);

c) an appreciation of the economic wealth derived from the Canadian Shield in Ontario (125, 131-32);

d) an open-mindedness towards the different theories proposed for the occurrence of minerals in the Sudbury Basin (125, 132).

112 Skills: Students will develop skill in:

a) plotting data on a map of Ontario (125, 131, 191);

b) inferring impact craters from topographical and geological maps (121, 125, 132, 192);

c) organizing, in proper sequence the major events in the Precambrian era (123).

113 Knowledge: Students will be expected to:

a) state the astronomical events that occurred during the initial stages of the earth's formation (121);

b) recall the extent of the Precambrian era, how it is defined, and why it is difficult to decipher (123);

c) state according to accepted geological theory how and when the oceans and atmosphere formed (122);

d) list the main types of Precambrian rocks found in Ontario and where they are found (124);

e) describe how life is thought to have originated during the precambrian era (124);

f) describe the type of fossils found in Precambrian rocks e.g., bacteria algae, viruses (124);

g) list some common minerals associated with Precambrian ores that are found in Ontario and state where they are found (123, 125, 131, 192);

h) outline the significance of greenstone belts and diabase sills to mineral occurrence (123, 125, 131, 192).

120 TOPICS

121 Crystallization of the interior of the earth

122 Origin of atmosphere and oceans

123 Precambrian rocks and history

124 Origin of life - Precambrian fossils

125 Economic importance

130 STUDENT ACTIVITIES

All of the following activities are mandatory. Students are to:

131 plot mineral occurrences on a suitable map of Ontario (191);

132 write a report on at least two case histories of mining districts in Ontario, e.g., Sudbury, Cobalt, Hemlo, Blind River, Timmins (192).

140 APPLICATIONS

141 New ore body locations can be inferred from what is known

about present ore bodies in the Precambrian rocks of Ontario.

142 What has been known about primitive life in the Precambrian can be applied to a search for extraterrestial neighbours in space.

150 SOCIETAL IMPLICATIONS

151 Miners and their families suffer dislocation problems when ore bodies become "worked out".

152 Pollution problems related to the atmosphere and hydrosphere are created in old mining towns.

153 New technology being developed will remove the ore from the ground faster, thus shortening the life of a mine, and in some cases, eliminating building a townsite near new mines.

160 EVALUATION OF STUDENT ACHIEVEMENT

At least 30 per cent of the term mark for this unit is to be based on the following two components:

161 written or oral report of the case history of two mining districts in Ontario;

162 plot of a map of mineral occurences in Ontario.

170 SOME SAFETY CONSIDERATIONS (See Part I)

180 POSSIBLE EXTENSIONS

181 Compare the Precambrian surface features of Canada to the surface features of Mercury, Mars, and Moon.

182 Discuss the effect that glaciers had in removing earlier shallow ore bodies.

183 Discuss the possibilities of finding diamonds in the Precambrian Shield.

190 SOME TEACHING SUGGESTIONS

191 Have students plot the location of different minerals on a map of Ontario.

192 Have students write reports on the different mining districts in Ontario's portion of the Precambrian Shield. Include benefits to Canada, employment opportunity, dislocation of families, environmental issues.

193 Use visual media to reinforce the economical aspects of mining.

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Geology - Grade 12 Advanced Level

Option Unit #2

PALEOZOIC ROCKS Time: 6 h

200 INTRODUCTION

The Paleozoic rocks which overlap the Precambrian Shield have formed through extensive sedimentation processes. Although at one time much more extensive, the present rocks are concentrated into two major regions, the Hudson Bay Lowlands and the St. Lawrence Lowlands of Southern Ontario. Extending over a time period of approximately 350 million years following the Precambrian Era, the Paleozoic was dominated by the invertebrate lifeforms. The students should therefore be directed towards both a physical and a biological overview of the events of this era. To establish a significance to the Paleozoic in Ontario, an economic evaluation can then be carried out.

210 OBJECTIVES

211 Attitudes: Students will be encouraged to develop:

a) an appreciation for the events which have marked the geological history of Ontario (221-225, 232-33, 241, 292-93);

b) a questioning attitude towards the evidence used to interpret the geologic events which have shaped Ontario (222-24, 232-33, 241-42, 292-93).

212 Skills: Students will develop skill in:

a) plotting data on maps to delineate boundaries (221, 231, 292);

b) constructing to scale a diagramatic section of rock layers (222-23, 232, 242, 291);

c) interpreting geological information as evidence for a sequence of events (222-23, 232-33, 241-42, 293).

213 Knowledge: Students will be expected to:

a) define the boundaries of the Paleozoic at the Precambrian contact (221, 231, 242, 292);

b) state the geologic time periods contained within the Paleozoic Era (222, 232-33, 241-42, 292);

c) recognize the predominant rock formations which have characterized the Paleozoic Era within each period (222-25, 232-34, 242, 251, 292);

d) identify the major fossil assemblages which were predominant during the Paleozoic (223, 233, 241, 293);

e) apply the Law of Superposition to interpret a succession of sedimentary rock layers (222, 232-34, 242, 291);

f) describe the economic significance to be derived from the Paleozoic rock in the form of oil, gas, lime, salt, gypsum, aggregate and building stone;

g) explain the stratigraphy and the formation of the Niagara Escarpment and the impact it has had on Southern Ontario (224, 232, 251).

220 TOPICS

221 Nature and extent of the Paleozoic in Ontario

222 The history of the Paleozoic and its divisions

223 Biological evidence within the Paleozoic Era

224 Niagara Escarpment

225 Economic resources

230 STUDENT ACTIVITIES

All of the following activities are mandatory. Students are to:

231 plot reference data such as place names on a map of Southern Ontario which will enable them to delineate the divisions of the Paleozoic rocks (292);

232 construct a columnar diagram to scale of a rock section taken from Southern Ontario (291);

233 study a fossil assemblage such as that of the brachiopod or the trilobite through the Paleozoic Era (293);

234 construct a flow diagram to illustrate the operation of a limestone quarry or a salt mine.

240 APPLICATIONS

241 Fossil evidence as preserved in Paleozoic rocks provides a key to evolution.

242 Information gained through the study of one rock section can be applied to other locations to derive economic awareness.

250 SOCIETAL IMPLICATIONS

251 Development on unique features such as the Niagara Escarpment must be controlled to maintain the aesthetic values.

252 Caution must be exercised when abandoned salt mines are used as storage facilities for natural gas.

260 EVALUATION OF STUDENT ACHIEVEMENT

At least 30 per cent of the term mark for this unit is to be based on the following components:

261 mapping and construction exercises

270 SOME SAFETY CONSIDERATIONS (See Part I)

280 POSSIBLE EXTENSIONS

281 Construct a fence diagram as an extension to activity 232 to illustrate the rock sequences from the Ordivician to Devonian.

282 Construct a cross-section of the Niagara Escarpment to reinforce its impact on the economy of Southern Ontario.

283 Plot and explain the location of quarry operations in Ontario.

284 Locate the oil/gas wells or salt mines in Ontario and determine which rock formations they are associated with.

285 Organize a field trip to either an abandoned or working quarry for studies on rock formations, fossil types or economics.

290 SOME TEACHING SUGGESTIONS

291 For construction of columnar diagrams, the teacher and students should agree on one common scale to maintain a degree of uniformity in the exercise.

292 Constant reference should be made to the relationship between Precambrian and Paleozoic. Students lose sight of the fact that the Paleozoic is underlain throughout by the Precambrian.

293 Try to have available to the students either hand samples or effective visual aids to illustrate fossil assemblages.

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Geology - Grade 12 Advanced Level

Option Unit #3

GLACIATED TERRAIN Time: 6 h

300 INTRODUCTION

The Ice Age, which is marked by the Pleistocene Epoch represents the final major event in the geologic evolution of Ontario. It should be noted that although the period of actual glaciation was of great significance, the deglaciation period must be considered equally so. Students must become aware that the basic patterns of relief and drainage evident today in Ontario owe their existence to both these stages of the Pleistocene.

310 OBJECTIVES

311 Attitudes: Students will be encouraged to develop:

a) an open-mindedness when confronted with theory (321, 325, 333, 351);

b) an appreciation for the impact the Ice Age has had not only on the physiography of the land but also the civilizations that dwelt there (323-24, 331, 341-42);

c) a questioning attitude towards a possible future Ice Age (325, 351).

312 Skills: Students will develop skill in:

a) evaluating theories on the origins of ice ages (321, 325, 333, 351);

b) interpreting from topographic maps, and air photographs the evidence left by glaciation and deglaciation (323-34, 331, 341-42, 391-92);

c) inferring glacial behaviour and effect from diagrams and slides (323, 332).

313 Knowledge: Students will be expected to:

a) state the theories put forth by glaciologists to explain the occurrence of continental glaciation (321, 333, 351);

b) describe the extent of the continental glacier as virtually covering all of Canada (322);

c) describe how environments change with glacier advance and retreat (322, 325, 333, 393);

d) compare and contrast the effects of glaciation and deglaciation (323, 331-32, 341-42, 391);

e) identify features associated with continental glaciation (323-24, 331-32, 393);

f) analyze the significant role the Ice Age has had in the economic development of Ontario (323, 331, 341-42, 391).

320 TOPICS

321 Origins of ice ages

322 Extent and nature of the continental glaciation

323 Glaciation and deglaciation in Ontario

324 The glacial record in Ontario - Peterborough

325 Is the Ice Age coming

330 STUDENT ACTIVITIES

All of the following are mandatory. Students are to:

331 analyse a topographic sheet from a selected area such as Peterborough (391);

332 identify from airphotos slides or diagrams the features of glaciation and deglaciation previously described to them (391-392);

333 discuss the possibility of another Ice Age and the impact it would have on our civilization (393).

340 APPLICATIONS

341 The nature of deposition put down by glacier activity in the southern portions of Ontario has influenced the land use.

342 The erosion of the Canadian Shield by glacier advance has simplified the exploration and recovery of minerals.

350 SOCIETAL IMPLICATIONS

351 The presence of ground ice and permafrost constantly reminds us that the renewal of glacial activity is very possible.

360 EVALUATION OF STUDENT ACHIEVEMENT

At least 50 per cent of the term mark for this unit is to be based on the following three components:

361 map interpretation;

362 participation in class discussion;

363 review and identification tests.

370 SOME SAFETY CONSIDERATIONS (See Part I)

380 POSSIBLE EXTENSIONS

381 Study the extent of the Ice Age on a world scale to gain a broader perspective of climate and continental glaciers.

382 Organize a field study to a well-defined glaciated area.

383 Discuss construction problems in permafrost regions.

390 SOME TEACHING SUGGESTIONS

391 Because of the complexity involved in analyzing the glaciation and deglaciation of Ontario, it is suggested that emphasis be placed on the local area as a focus of glacial activity.

392 The Peterborough region is suggested as a case study area because it is located near the contact of the resistant Precambrian erosion surface and the sedimentary Paleozoic.

393 Student attention should be focused on climatic trends and related events in discussing the Ice Age.

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Geology - Grade 12 Advanced Level

Option Unit #4

THE GREAT LAKES

Time: 6 h

400 INTRODUCTION

Most students will know of the Great Lakes but will not realize that they are a geological heritage from the Ice Age, nor will they realize that they are still undergoing physical changes. These changes result from crustal and erosional processes which can be measured and charted. Thirty seven million people cluster around the shores of the lakes. Students must be led to understand nature's ways with respect to the lakes and make allowance for the laws that govern the changes to them. In this way society can learn to live with the lakes and maintain their potential as a resource.

410 OBJECTIVES

411 Attitudes: Students will be encouraged to develop:

a) a commitment to learn more about the laws governing the changes to the great lakes and to help maintain the lakes in a useable condition.

412 Skills: Students will develop skill in:

a) interpreting, from topographic maps and from air photographs, the evidence for the presence of the ancestral Great Lakes;

b) obtaining the evidence for crustal tilting following the retreat of the last glaciers;

c) identifying the effect of crustal tilting on the evolution of the lakes and the effect on the lakes today;

d) obtaining, organizing and analysing the data from lake level gauges over the last 50 years to measure the rate of present-day crustal tilting;

e) gathering and interpreting historical data, i.e., maps and photographs, to demonstrate the change in shorelines in a given area, and deducing the reasons for the change.

413 Knowledge: Students will be expected to:

a) identify the principle geographic, geological, hydrographic and bathymetric features of the Great Lakes;

b) explain the evidence for deciphering the evolution of the Great Lakes drainage basin in the past 15 000 years (421);

c) list the factors involved in the changing patterns of the ancestral Great Lakes particularly with respect to shoreline (423);

d) define the terms spits, bars, and beaches (423);

e) establish the time-frame for the history of the Great Lakes on the basis of Carbon - 14 (421);

f) identify those shoreline environments that are susceptible to severe erosion (425);

g) apply a knowledge of shoreline environments to the land-use zoning of one of the great lakes (426).

420 TOPICS

421 The evolution of the Great Lakes

422 The fluctuating lake levels

423 Shoreline processes

424 The effect of engineering structures on shoreline processes

425 Factors involved in shore erosion

426 Land-use zoning of shore lines

430 STUDENT ACTIVITIES

All of the following activities are mandatory. Students are to:

431 interpret topographic maps and air photographs and summarize the history of the Great Lakes;

432 examine both ground level and air photographs to demonstrate shoreline processes and the effect of engineering structures on these processes;

433 visit a beach on any lake to study the beach profile, the sorting of the sedimentary particles that make up the beach, and the shoreline processes;

434 draw a contour map to illustrate the rate of present day crustal tilting;

435 write a paper on coastal-environments erosion and shore damage,

OR

write a paper on the problems involved in controlling lake levels.

440 APPLICATIONS

441 Knowledge of the behaviour of the waters of the Great Lakes, and the rules they follow is essential for shoreline management and development.

442 Knowledge of coastal processes is essential for land use planning along the shores of the Great Lakes.

443 Knowledge of crustal tilting is essential in planning mega-projects on the Great Lakes.

450 SOCIETAL IMPLICATIONS

451 Information will be provided that can lead to well-informed opinions by students on how the Great Lakes can be maintained as a multi-use natural resource.

452 An understanding of the problems that can arise if waters are diverted from the Great Lakes causing a reduction of lake levels can help society deal with the many schemes proposed to divert Great Lakes water.

460 EVALUATION OF STUDENT ACHIEVEMENT

At least 40 per cent of the term mark for this unit should be based on the following three components:

461 drawing of contour maps;

462 interpretation of topographic maps and air photos;

463 written paper as outlined in activity 435.

470 SAFETY CONSIDERATIONS (See Part I)

471 If a trip to a beach is undertaken water safety should be practised. Steep and undercut cliffs should be avoided.

480 POSSIBLE EXTENSIONS

481 Discuss the use of fossil pollen obtained from cores and samples of sediments deposited in the Great Lakes past and present to establish a chronology for lake histories.

482 Describe the use of geophysical techniques for mapping the bottoms of the Great Lakes.

483 A more detailed explanation of the use of Carbon-14 in establishing the time-frame for the geological history of the Great Lakes could be undertaken.

490 SOME TEACHING SUGGESTIONS

491 Keep an awareness board in the class-room to post news items with respect to the Great Lakes.

492 Visit the municipal offices of those municipalities that are concerned with shoreline properties on the Great Lakes.

493 Relate shoreline damage to the cost of property loss.

494 Use AV material to illustrate dynamic shoreline processes.

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Geology - Grade 12 Advanced Level

Option Unit #5

THE DRAINAGE BASIN

Time: 6 h

500 INTRODUCTION

Students will be aware of the hydrologic cycle and the fact that the valleys in which rivers flow were either formed by the rivers, or have been modified by the rivers, and that the formation of the valleys involves the removal of sediment. Students will also be aware of the fact that every river has tributaries that diminish in size as the distance from the main or trunk river increases. Students will then be encouraged to understand that the main trunk river and its tributaries form a drainage basin, also known as a watershed*. Each drainage basin is clearly separated from its neighbours and forms a distinct, finite, and fundamental geomorphic unit that contains a fluvial system in the form of an organized drainage net that has evolved. As such, drainage basins form a natural unit for land use and resource planning.

* N.B. In most legislative documents the term watershed is used.

510 OBJECTIVES

511 Attitudes: Students will be encouraged to develop:

a) an appreciation of the effect of human development on fluvial events;

b) a commitment to work towards the environmental enhancement and preservation of local watersheds.

512 Skills: Students will develop skill in:

a) analysing, using semi-log paper, a drainage net to establish its form, the stream orders, the trunk stream and the principal segments or parts of a drainage basin (521-22, 534);

b) determining the stream profile of the trunk stream in a drainage basin and analysing its shape from a topographic map (523, 532);

c) identifying the sediment load of a river and its mode of transport and deposition (525, 536);

d) identifying the variables in a river such as its gradient, width, depth, velocity, discharge, sediment load, thalweg, meander belt (523-26, 532-33);

e) identifying the headwaters, floodplain and the base level of a drainage basin (524, 532).

513 Knowledge: Students will be expected to:

a) define and/or use the following terms:

drainage basin or watershed; runoff; drainage net; precipitation; discharge; return period (recurrence) interval; stream velocity; sediment; sediment load;

stream order number; stream profile; base level; meander; sinuoisty; thalweg; hazard land; flood; headwaters, floodplain; bank full; flow duration curves; trunk stream (521-26, 531-37);

b) recognize the form of a drainage basin (522, 531-32);

c) use stream order numbers to demonstrate the orderliness of a drainage basin (522, 534);

d) compare and apply the fluvial functions of the headwaters, floodplain and base level in a drainage basin (524, 535);

e) apply discharge data to develop a flow duration curve, and calculate return (recurrence) intervals of fluvial events (525, 535);

f) identify the relationship between stream velocities, sediment load and discharge (525-26, 536);

g) describe the factors determining the geometry of a river and identify segments where erosion and sedimentation occur (526, 536-37).

520 TOPICS

521 The hydrologic cycle (review)
522 Drainage basins
523 The analysis of the profile of the trunk steam
524 Headwaters, floodplain and base level
525 Fluvial events
526 The geometry of rivers

530 ACTIVITIES

Activities 531-35 are mandatory. Students are to:

531 prepare a diagram of the hydrologic cycle as it applies to a drainage basin;

532 identify drainage basins and their form on suitable topographic maps (593);

533 from suitable topographic maps, draw the profiles of the trunk stream and determine the gradient (593);

534 analyze the stream orders of a drainage basin and establish the organization of the drainage net using semi-log graph paper (593);

535 prepare graphs to illustrate the flow duration and return periods (recurrence intervals) of a given river;

536 establish the relationship between stream velocities and sediment loads, and the particle size of the transported sediment by taking measurements at a local stream (592);

537 establish the geometric properties of a meander and the segments of a meander where erosion and sedimentation occur.

540 APPLICATIONS

541 Understanding the fluvial processes within a drainage basin provide the basis for land use planning, water conservation, and resource management.

542 The analyses of drainage basins provide the basis for determining the denudation of a continent.

543 Data derived from the study of drainage basins allow an

assessment of the water supply of political units - i.e., provinces and countries.

550 SOCIETAL IMPLICATION

551 Knowledge of the changes that have taken place over time in a drainage basin provide a better understanding of many environmental problems.

552 A drainage basin provides the best geomorphic unit for land use planning, and coping with changes brought about by urbanization.

560 EVALUATION OF STUDENT ACHIEVEMENT

At least 50 per cent of the term mark for this unit is to be based on the following three components:

561 proficiency in preparing a diagram of the hydrologic cycle;

562 proficiency in reading and interpreting drainage-basin information from topogrpahic maps;

563 proficiency in preparing graphs in activities 534-35.

570 SAFETY CONSIDERATIONS (See Part I)

580 POSSIBLE EXTENSIONS

581 Write a report on the changes produced in a major drainage basin by dam construction of the trunk stream e.g., the Bennet Dam on the Peace River.

582 Engage the class in a discussion on the question of whether or not "runoff" (water surplus) means the Ontario has "water for sale".

583 Investigate the problems associated with drainage basins that are divided by political boundaries.

584 Identify the effects of urban activities with fluvial processes.

585 Investigate the post-glacial history of a local watershed.

590 TEACHING SUGGESTIONS

591 Obtain as much data and illustrative material as possible that pertain to the drainage basin in which the school is located.

592 Have students measure stream velocities and discharge in the field whenever possible.

593 Have a good selection of maps and air photographs available, so that, with students divided into teams, comparative data can be obtained for such activities as stream profiles, the form of a drainage basin, and meander analyses.

594 Obtain copies of various government documents with reference to drainage basins (watersheds).

595 Use this unit in conjunction with OU 3 - The Glaciated Terrain or OU 6 - Groundwater.

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Geology - Grade 12 Advanced Level

Option Unit #6

GROUND WATER

Time: 6 h

600 INTRODUCTION

Groundwater, being derived almost entirely from precipitation, is very significant to the hydrologic cycle as water is returned from the land to the sea. Too often however, its presence as a renewable resource has been taken for granted and the effectiveness of the cycle becomes diminished when withdrawal of groundwater exceeds the recharge. Apart from the important scientific aspects of groundwater to be considered in this unit, students may also become aware of the social and economic aspects.

610 OBJECTIVES

611 Attitudes: Students will be encouraged to develop:

a) a respect for the role groundwater assumes in the maintenance of an effective hydrologic cycle (621-22, 632, 692-93);

b) an appreciation for the geologic work carried out by groundwater in its interaction with the earth's crustal rock (621-22, 624, 631, 642, 691-93);

c) a concern for the demands being placed on groundwater reserves without sufficient consideration for resource renewal (623, 632, 641, 651, 693);

d) a commitment to the conservation of not only groundwater resources but all natural resources (623, 641, 651).

612 Skills: Students will develop skill in:

a) observing, under simulated conditions, groundwater processes (621-22, 624, 631, 642, 691);

b) controlling variables to establish groundwater behaviour (621-22, 624, 631, 691);

c) graphing groundwater levels using data obtained from observation wells (622-23, 632, 641, 651, 693);

d) interpreting from hydrographs the fluctations noted in water levels (622-23, 632, 641, 651, 693).

613 Knowledge: Students will be expected to:

a) define within the scope of hydrogeology the following terms: aquifer, head, infiltration, permeability, porosity, karst, percolation, saturation, water table (621-24, 631, 642);

b) explain the role of groundwater as a storage reservoir in the hydrologic cycle (621-22, 631, 641, 651`;

c) describe how movement of groundwater is controlled by physical properties of rocks (622, 631, 642, 691, 693);

d) state the control factors which govern the recharge to groundwater (622-23, 632, 641, 651, 693);

e) recognize a groundwater system as an open system in each segment of which a state of dynamic equilibrium is approached (621-22, 641, 651, 693);

f) state the effects that the withdrawal of groundwater from an aquifer will have (623, 632, 641, 651, 693);

g) explain how groundwater assumes a role in the rock cycle being equally effective in solution and cementation processes (624, 631, 642, 691, 693);

h) explain the principles of fluid dynamics in a permeable medium;

i) describe the contribution of groundwater to a baseflow of a river.

620 TOPICS

621 The nature of groundwater

622 Movement of groundwater

623 Economics of groundwater

624 Geologic work by groundwater

630 STUDENT ACTIVITIES

All activities are mandatory. Students are to:

631 observe through simulation, the movement of groundwater through sand (691);

632 prepare a hydrograph to record water-level fluctations for data obtained from test wells (693).

640 APPLICATIONS

641 Knowledge of groundwater levels is a prerequisite to good

groundwater management.

642 The development of unique karst topography is the result of minerals going into solution in groundwater.

650 SOCIETAL IMPLICATIONS

651 With the increase in population and industrialization, the demand for water is growing very rapidly. The basic principle of conservation must be that withdrawal of groundwater never exceed recharge.

660 EVALUATION OF STUDENT ACHIEVEMENT

At least 30 per cent of term mark for this unit is to be based on the following three components:

661 interpretation and analysis of groundwater-related graphs and diagrams;

662 participation in group activities and class discussions.

670 SOME SAFETY CONSIDERATIONS (See Part I)

680 POSSIBLE EXTENSIONS

681 Do a case study of the Bonnechere Caves in eastern Ontario.

682 Visit a water treatment plant to observe purification of water under conditions similar to the underground.

683 Visit a town with a water supply system.

690 SOME TEACHING SUGGESTIONS

691 Transparent dishes with water coloured by ink will best illustrate movement of water through sand.

692 It may be in the best interest of the students to have a review of both the hydrologic and the rock cycles at the beginning of the unit.

693 This particular unit lends itself well to the use of diagrams and graphs to illustrate the behaviour of groundwater. There should therefore be an emphasis on visual aids to assist the student in the understanding of groundwater.

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Geology - Grade 12 Advanced Level

Option Unit #7

GEOPHYSICAL EXPLORATION Time: 6 h

700 INTRODUCTION

The age of electronics has brought some quite astonishing improvements in man's ability to observe things at a distance and to make measurement of hidden objects. Four quite different variations of this theme, namely, remote sensing (particularly from satellites), seismic, magnetometer, and electromagnetic investigations are considered in this unit. All four use sophisticated computer techniques and all four are of great importance in the increasingly difficult search for new resources of raw materials.

710 OBJECTIVES

711 Attitudes: Students will be encouraged to develop:

a) an appreciation for geophysics as an exploration tool for resources (721-24, 734, 741-44);

b) a respect for Canadian worldwide leadership in geophysics (721-24);

c) an appreciation of the instruments used in geophysics (721-24, 741-44).

712 Skills: Students will develop skill in:

a) using measurements to refine their observations (721-24, 731-35, 741, 744);

b) repeating observations to make them more reliable (722);

c) inferring on the basis of observations (721-24, 731-36);

d) using tables, graphs and maps to record data (721-24, 731-33, 791).

713 Knowledge: Students will be expected to:

a) explain the principles of seismic investigations (721, 741);

b) explain the principles of magnetic investigations (722, 742);

c) explain the principles of electromagnetic investigations (723, 743);

d) be familiar with the different types of electromagnetic investigations (723, 743);

e) explain the principles of the different types of remote sensing instruments (724, 743);

f) define or correctly use the term anomaly (721-24, 733);

g) infer basic characteristics of anomalous conditions (721-24);

h) determine which geophysic method is best suited for a given area (721-24);

i) define or correctly use the terms reflection, refraction, gamma resistivity, cross-overs and pixels (721-24).

720 TOPICS

721 Seismic methods

722 Magnetic methods

723 Electric and electromagnetic methods

724 Remote sensing by satellite

730 STUDENT ACTIVITIES

All of the following activities are mandatory. Students are to:

731 plot seismic profiles from given data (721, 791);

732 plot and interpret a simple time vs distance curve (721, 791);

733 plot, contour, and make graphs of magnetic data (722, 794);

734 conduct a simple magnetic investigation using compasses (722)

735 plot and interpret given electromagnetic data (723);

736 make inferences regarding an area after viewing different remote-sensing images of that area (724).

740 APPLICATIONS

741 Seismic principles are used:

a) in the search for oil, gas and water;

b) in earthquake studies;

c) by engineers to study the nature of materials for construction;

d) by the medical profession in ultra sound;

e) in radar.

742 Magnetic principles are used:

a) in the mining industry to locate magnetic materials associated with mineral resources;

b) in locating buried iron pipes, nails, etc.;

c) in removing iron objects, such as nails from highways;

d) in navigating and orienteering;

e) to make dip and strike measurements;

f) in paleomagnetic studies.

743 Electric and electromagnetic principles are used:

a) in search for metallic minerals by the mining industry;

b) in search for submarines by the military;

c) in resistivity investigations for ground water;

d) to find buried treasure.

744 Remote sensing imagery is used:

a) by mining industry to obtain large area coverage of a region to locate suitable areas for investigation;

b) by environmental agencies to monitor pollution;

c) by agriculture agencies to determine crop yields and diseases;

d) by scientists to locate geothermal energy sites;

e) extensively in space research.

750 SOCIETAL IMPLICATIONS

751 Geophysical methods are used in locating non-renewable supplies of fossil fuels for industry.

752 One of Canada's major exports is raw materials.

753 Geophysical technology provides the means of locating Canada's valuable mineral resources which produce many useful products.

754 Geophysical techniques are now being applied by the medical profession in treating patients (i.e., radiation, ultrasound etc.).

760 EVALUATION OF STUDENT ACHIEVEMENT

At least 40 per cent of the term mark for this unit is to be based on the following components:

761 plotting seismic profiles;

762 plotting graphs of magnetic data and distance vs time.

770 SOME SAFETY CONSIDERATIONS (See Part I)

771 When using voltage supply equipment, be careful not to exceed the correct voltages. Caution students to disconnect the power supply by pulling the plug, not the cord. Use CSA approved equipment only.

780 POSSIBLE EXTENSIONS

781 Study material on the life and accomplishments of a Canadian geologist such as Dr. Tuzo Wilson.

782 Design model studies for magnetic investigations

783 Design and conduct model studies for electromagnetic investigations.

784 Bury a large iron object in the back of the school yard and attempt to find it with a compass.

790 SOME TEACHING SUGGESTIONS

791 Tables and graphs should be used whenever they are appropriate.

792 It is essential for all students to take part in the activities.

793 Use visual media to reinforce the different instruments and techniques.

794 Have students contour geophysical data whenever they are appropriate.

795 Use case histories to illustrate the different geophysical methods.